Notice of Allowability	Application No.	Applicant(s)
	10/734,945	CRKVENAC ET AL.
	Examiner	Art Unit
	George Nguyen	3723

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☐ This communication is responsive to _____.

2. ☒ The allowed claim(s) is/are *1-10*.

3. ☒ The drawings filed on *11 December 2003* are accepted by the Examiner.

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☐ All b) ☐ Some* c) ☐ None of the:
      1. ☐ Certified copies of the priority documents have been received.
      2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
      3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.

6. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
      1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

7. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☒ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☒ Information Disclosure Statements (PTO-1449 or PTO/SB/08), Paper No./Mail Date 040904 and 072204
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application (PTO-152)
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☐ Examiner's Amendment/Comment
8. ☒ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

GEORGE NGUYEN
PRIMARY EXAMINER

REASONS FOR ALLOWANCE

1. The following is an examiner's statement of reasons for allowance: the specific limitations of "determining a critical rotation rate of the article ... polishing layer" in the combination as claimed in claim 1; and "selecting one of a backmixing mode for ... chemistries" in the combination as claimed in claim 8 are not anticipated nor made obvious by the prior art of record in the examiner's opinion. For example, Mandigo et al.'6,602,436 discloses a method of polishing a wafer in a carrier by a polishing pad, controlling a ratio of platen speed to carrier speed (PS to CS) within a specific range, or controlling a first polishing step with a PS to CS ratio in the range of about 150:1 to 1:150 followed by a second polishing step with a platen speed of about 0 to 20 rpm while maintaining the carrier speed used in the first polishing step, which maximizes clearing of residual material removed from patterned wafer surface by polishing.

EXAMPLE 3

A polishing test was run on the AMAT Mirra polishing machine utilizing copper material sheet wafers as the substrate; a metals 26 (K-X-Y Groove) polishing pad; and a GPM 1000 sub-pad. Both pads are manufactured by Rodel, Inc. A developmental polishing fluid, GRP-06, also manufactured by Rodel, Inc., was used at a flow rate of 200 ml/min. The impact of various carrier speed values on copper material removal rates at different diameter scan points was investigated further for a fixed platen speed of 100 rpm and downforce of 5 psi. The pad was preconditioned for 20 minutes utilizing a 100 grit diamond disk (manufactured by Abrasive Technology, Inc.). A down force of 10 psi and a platen speed of 63 rpm was used for all conditioning steps. All tests were duplicated on two wafers. Thus each data point on FIG. 7 and FIG. 8 is an average of data collected from identical tests on two wafers. A conditioning step of 20 second duration was also performed between wafer runs. Each wafer was polished for a duration of 60 seconds.

As shown in FIG. 7, holding the platen speed constant at 100 rpm at a downforce of 5 psi, and increasing the carrier speed from 90 to 175 rpm, created an edge fast process. The PS to CS ratio in this experiment ranged from 1.1:1 to 0.57:1. However, raising the PS to CS ratio from 1.1:1 to 4:1, all other test conditions being equal, yielded uniform removal rates across the wafer surface. FIG. 8 illustrates the uniformity of removal rates observed by dropping the carrier speed for a fixed platen speed of 100 rpm and a downforce of 5 psi, i.e., increasing the PS to CS ratio from 1.1:1 to 4:1. With a different slurry, comparable results are expected for a PS to CS ratio of about 1:4 to 1:1.1.

EXAMPLE 4

A SEMATECH 931 wafer with an initial copper material thickness of 15,000 angstroms was polished on the AMAT Mirra polishing machine using a metals 26 (K-X-Y Groove) polishing pad; a GPM 1000 sub-pad and GRP-04 polishing fluid at a platen speed of 100 rpm; a downforce of 5 psi; and a carrier speed of 15 rpm. A down force of 10 psi and a platen speed of 63 rpm was again used for all conditioning steps. The duration of this polishing test was 100 sec. Such polishing substantially removes the copper material, except for leaving residuals of the material on the patterned wafer. The patterned wafer was further polished but at a reduced platen speed of 20 rpm with the carrier speed at 15 rpm utilizing the same polishing fluid and conditioning steps. The duration of this polishing test was 40 sec. The patterned wafer after the second polishing step has insignificant or minimized residuals of the material to be removed by polishing. The reduced platen speed during the second polishing step increases the residence time of the polishing fluid on the polishing pad thereby increasing removal of residual copper material. It should be noted that the copper material layer thickness at the end of the first polishing step is in the range of about 500 to 1000 Angstroms. Thus, increasing the residence time of the polishing fluid on the polishing pad by decreasing platen speed during the second polishing step enhances removal of residual copper material on the patterned wafer surface. This effect will be enhanced when grooved pads with different groove designs are used for polishing the semiconductor substrate.

The CMP method of the present invention involves changing the PS to CS ratio to minimize wafer non-uniformity (less than 3%) across the semiconductor wafer surface. The method of this invention presents a first polishing step with an operating PS to CS ratio in the range of about 6:1 to about 1:1 (preferably about 6:1 to 2:1 and most preferably about 2.5:1); followed by a second polishing step with a platen speed of about 0 to 20 rpm while maintaining the carrier speed used in the first polishing step to maximize clearing of residual copper material from a patterned wafer surface due to increased residence time of the polishing fluid on the polishing pad. With a different slurry, comparable results are expected for a first polishing step with an operating PS to CS ratio in the range of about 1:6 to about 1:1 (preferably about 1:6 to 1:2 and most preferably about 1:2.5); followed by a second polishing step with a platen speed of about 0 to 20 rpm while maintaining the carrier speed used in the first polishing step to maximize clearing of residual copper material from a patterned wafer surface due to increased residence time of the polishing fluid on the polishing pad.

The following claims define this invention and should be accorded the broadest possible interpretation to encompass all modifications obvious to one skilled in the art.

What is claimed is:

1. A method for chemical-mechanical planarization of a metal layer on a semiconductor wafer, comprising:

i. affixing the wafer in a rotatable carrier of a polishing machine, and rotating the carrier at a rotational carrier speed, CS;

ii. affixing a polishing pad to a rotatable platen of the polishing machine, and rotating the platen at a rotational platen speed, PS, wherein the ratio of PS to CS is in a range of 2:1 to 10:1 and

iii. contacting the wafer and the polishing pad with a fixed down force while maintaining relative motion therebetween, while dispensing a polishing fluid at an interface of the wafer and the polishing pad, the polishing fluid containing less than 0.01 weight percent abrasives, to provide a planarized surface of the wafer.

2. The method of claim 1 wherein the ratio of PS to CS has the range of 2:1 to 6:1.

3. The method 1, wherein the fixed downforce is in a range of about 1 to 10 psi.

4. The method of claim 1 wherein the fixed downforce is in a rang of about 1 to 5 psi.

5. The method of claim 1 wherein the polishing pad is an abrasive-free pad.

6. The method of claim 1 wherein the polishing fluid has a pH under 5 and further includes:

i. polyacrylic acid having a number average molecular weight of about 20,000 to 150,000;

ii. 1 to 15% by weight, based on the weight of the polishing fluid, of an oxidizing agent;

iii. 50 to 5000 parts per million by weight of an inhibitor; and

iv. up to 3% by weight, based on the weight of the polishing fluid, of a complexing agent.

7. The method of claim 6 wherein the polishing fluid has a pH of about 2.8 to 4.2 and the polyacrylic acid has a number average molecular weight of about 25,000 to 75,000 and is present in an amount of about 0.05 to 1.0% by weight, based on the weight of the polishing fluid.

8. The method of claim 6 wherein the metal is copper.

* * * * *

However, the prior art of record fails to provide or suggest the specific limitations of "determining a critical rotation rate of the article ... polishing layer" in the combination as claimed in claim 1; and "selecting one of a backmixing mode for ... chemistries" in the combination as claimed in claim 8.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Any inquiry concerning this communication or earlier communications from the examiner should be directed to George Nguyen whose telephone number is 703-308-0163. The examiner can normally be reached on Monday-Friday/630AM-300PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Joseph Hail can be reached on 703-308-2687. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

George Nguyen

Primary Examiner
Art Unit 3723

GN – September 22, 2004

GEORGE NGUYEN
PRIMARY EXAMINER